

CONCEPT: INTRODUCTION TO KIRCHHOFF'S LOOP RULE

- So far we have only seen SINGLE source circuits. To solve circuits with MULTIPLE sources, we will need new “TOOLS”

- Kirchhoff's LOOP rule states that the SUM of all the VOLTAGES around a LOOP is _____.

→ $\Sigma V = \underline{\hspace{2cm}}$ - This rule is also called Kirchhoff's _____ Law.

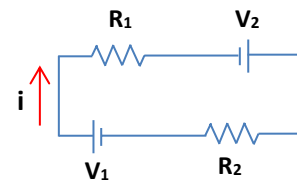
- This works for ANY circuit, but is especially useful for circuits with MULTIPLE sources.

- For each LOOP in a circuit, we can write one LOOP EQUATION.

- Each equation adds/subtracts voltages of batteries and resistors.

- The voltage of resistors is written as _____ (from _____)

→ $\Sigma V = \underline{\hspace{2cm}} = \underline{\hspace{2cm}}$



- Each voltage is added or subtracted depending on (1) DIRECTION OF CURRENT, and (2) DIRECTION OF LOOP.

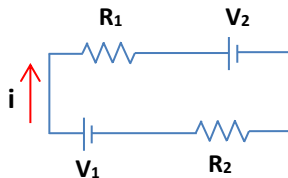
(1) **FIRST**, use DIRECTION of CURRENT to put +/- signs on the ends of each resistor:

- RESISTOR → Positive end is where _____ the resistor.

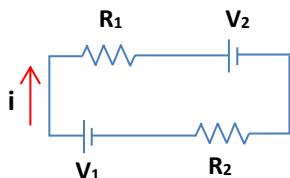
- BATTERY → Positive end is positive (longer) terminal (does not depend on direction of current)

(2) **SECOND**, choose DIRECTION OF LOOP, which is just the sequence in which we will add/subtract voltages.

- When “crossing” elements in this direction, you ADD a voltage if you crossed from _____ to _____.



EXAMPLE: Write a Loop Equation for the circuit above (repeated below), but now using the opposite Direction of Loop.



CONCEPT: DIRECTION OF CURRENT IN LOOP EQUATIONS

- In complex circuits, you often will **NOT** know the DIRECTION OF CURRENTS, so you will _____ / _____ them:

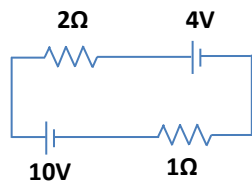
(0) **NEW:** _____ direction of ALL currents

(1) LABEL +/- Signs → Battery + is on longer terminal. Resistor + is where _____ enters the resistor.

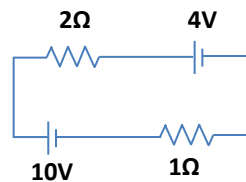
(2) “CROSS” elements in chosen DIRECTION OF LOOP, adding the voltage if you crossed from _____ to _____.

EXAMPLE: Write Loop Equations for the circuits below, based on the indicated direction of current, then find their current.

(a) current is clockwise



(b) current is counter-clockwise



CONCEPT: SOLVING CIRCUITS WITH MULTIPLE SOURCES

- We combine Kirchhoff's Junction Rule ($\sum I_{\text{IN}} = \sum I_{\text{OUT}}$) and Loop Rule ($\sum V = 0$) to solve circuits with MULTIPLE sources:

1) LABEL DIRECTIONS:

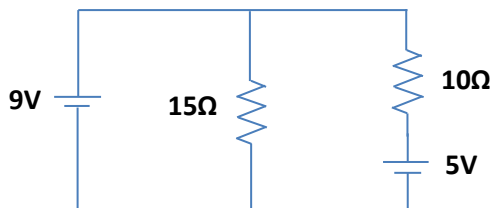
- LABEL Junctions, Loops (arbitrary) and direction of Currents (assumed)
- LABEL +/- on Voltage Sources (+ terminal) and Resistors (current enters)

2) WRITE EQUATIONS:

- WRITE a Junction Equation for each Junction
- WRITE a Loop Equation for each Loop

3) SOLVE SYSTEM OF EQUATIONS

EXAMPLE: For the circuit below, find the current through each of the 3 branches.

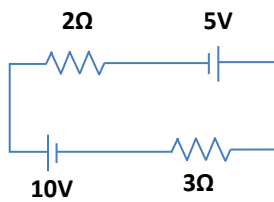


CONCEPT: COMBINING VOLTAGE SOURCES IN SERIES

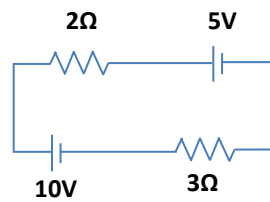
- You can combine Voltage Sources connected in SERIES to simplify the circuit $\rightarrow V_{EQ} = \underline{\hspace{2cm}}$
 - If the Voltage Sources are pushing charge in OPPOSITE directions, their voltages will .

EXAMPLE: For each circuit below, combine the batteries and resistors, then find the magnitude and direction of the current.

(a)

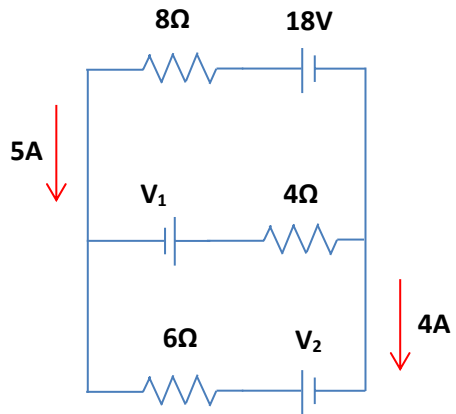


(b)



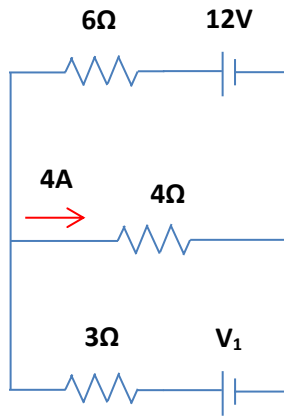
EXAMPLE: FIND TWO VOLTAGES IN 2-BATTERY CIRCUIT

For the circuit below, calculate voltages V_1 and V_2 .



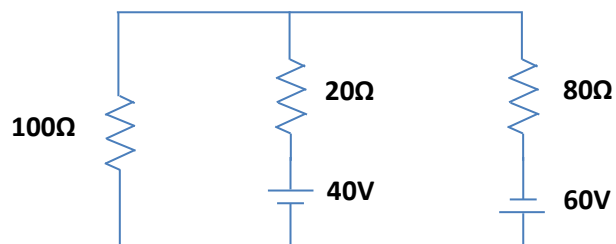
PRACTICE: FIND ONE VOLTAGE AND ONE CURRENT IN 2-BATTERY CIRCUIT

For the circuit below, calculate **(a)** the voltage V_1 shown, and **(b)** the current through the 6-Ohm resistor.



PRACTICE: FIND VOLTAGE OF ONE RESISTOR IN 2-BATTERY CIRCUIT

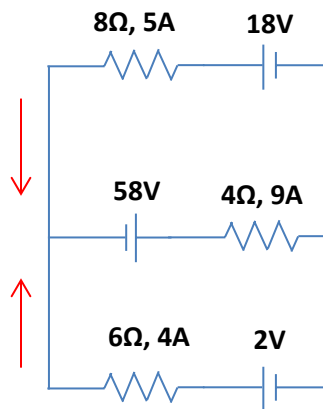
For the circuit below, calculate the voltage across the 100-Ohm resistor.



CONCEPT: HOW TO CHECK YOUR WORK (KIRCHHOFF'S RULES)

- Once you know ALL values (voltages, currents, and resistances) in a circuit, you can check your work with a simple rule:
 - ALL branches MUST have the same magnitude and “direction” (_____) of _____.

EXAMPLE 1: Check if all numbers below “match up”



EXAMPLE 2: Check if all numbers below “match up”

